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Date: August 14, 2016

RTCA Paper No. 200-16/SC230-021

EUROCAE WG-95 / RTCA SC-230 WG8 Plenary 4 (July 12 - 14, 2016) - Meeting minutes

Attendance list:

Name	Company	Attendance
Caruhel, Camille	Airbus	x
Merle, Jean-Michel	Airbus	x
Tschacher, Luke	The Boeing Company	x
Bravin, Melissa M	The Boeing Company	x
Mason, Jeanne	The Boeing Company	x
Ren, Yukun	The Boeing Company	x
Ahmed, Mohammed	The Boeing Company	x
Degard, Dan	The Boeing Company	x
Gidner, Dawn	Honeywell International, Inc.	x
Christianson, Paul	Honeywell International, Inc.	x
Bunch, Brian	Honeywell International, Inc.	x
Logan, Gloria	Honeywell International, Inc.	x
Lukas, Jan	Honeywell International s.r.o.	x
Finley, Jeff	Rockwell Collins, Inc.	x
Stover, Keith	Rockwell Collins, Inc.	x
Harrah, Steve	NASA	x
Campbell, Brian	ASAMEC Safety Committee (ALPA)	x
Machida, Shigeru	Japan Aerospace Exploration Agency (JAXA)	*
Grzych, Matthew L	The Boeing Company	*

** - Via Telecon/WebEx*
x - In person

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July 12th, 2016

Steve was able to share a TASS dataset for the HAIC event from the Darwin flight test case. They are going to work on similar data sets for known engine events caused by high altitude ice crystals (4 data sets provided to NASA by Boeing). The data will have weather information modeled for events the suppliers could use to validate their algorithms and eventually for use in the future potential MOPS. Steve estimated that we can maybe get ~1 data set per month for a total of 6 cases (Darwin, Florida, 4 Boeing engine events) by early next year.

Steve also presented a graph for reflectivity vs. total water content (TWC) to the team. Data is from 4-6 hours of flight at mostly 40,000 feet and some as low as 20,000 feet for the warmer data. There was a lengthy discussion on this graph and particularly the flattening of the reflectivity trend between 0.5 to 1.5 g/m^3. It is possibly due to smaller particles at the colder temperatures i.e. there are more small particles vs. less large particles, which show the same reflectivity. This brought on discussion as to what accuracy and range are really needed to be useful. Pilots (Jean-Michel) agreed that we aren't expecting precision, but long range estimates are needed…The Radar Ice Crystal function shall not be considered as an in-situ measurement.

Jeff provided some updates to section 5 - In summation, the data Steve presented is in general agreement (on the surface) with the data Jeff has entered into the report with regards to the relationship between reflectivity and TWC.

Action - It was expressed that we need to consider the analysis portion of how we would prove our probability of detection and false alert. Action 50 indicates that NASA shall provide data (TWC/Reflectivity) from its campaigns to Radar OEMs. Action 49 has been taken by Radar suppliers to assess with the already available data that the requested probability of detection and false alert could be reached.

Action - Engine/Probe Event Plots - It was recognized that the plots need to have the legends updated to change the legend to relate to 90% of engine events / 90% of probe events and consider changing 'activation' to 'display of'. It was also recommended that we soften the wording to be guidelines on where you would cover the majority of the events. This would allow for the radar manufacturers to do better if they could, but not limit the use of the function to those regions. *<Action item 56 in the 'EUROCAE WG-95 - Action Items' file will address this action>*

Action - After some discussion, it was determined that our radar manufacturers will provide information regarding the limitations of ice crystal detection from a radar perspective with respect to altitude and temperature. *<Action 51 in the 'EUROCAE WG-95 - Action Items' file will address this action>*

Action - There was some confusion as to the requirement for the higher threshold within the document (probe threshold). There was a request to update the document to point to the adiabatic curves (CFR 14 Part 33 Appendix D, Figure D2) and that if 20,000 feet is chosen, use 2 g/m3 if a higher altitude is chosen, use higher threshold (3 g/m3 at 25,000 ft). As a generic action it has been requested to define a realistic threshold considering all the available data as the in-service events and the adiabatic curves…

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At the end of the day, Shigeru Machida from JAXA provided a pitch on the progress and expectations for their LIDAR system to be used for clear air turbulence detection. The main objective of providing the pitch to this group was that the team is looking to incorporate performance standards in the 2018 timeframe and their team currently believes SC-230 may be a starting point for their standards activity. In the end, it was decided that JAXA may provide another update at the conclusion of their flight testing early next year and the request would be evaluated by RTCA when the time comes to help provide guidance on where the best home is for applicable standards.

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Radar OEMs are hesitant to move forward without more concrete rational or data available regarding what the problem space is (i.e. is 1 g/m3 the right threshold for commercial engines? Is 3 g/m3 correct for probes?) Do we need multiple thresholds or categories to cover certain types of aircraft? There was a request made to ensure the feasibility report clearly states the specific values provided within the document (i.e. moderate and high thresholds, must detect, must not detect probabilities, altitudes, temperatures, etc.) were the best available values at the time of the feasibility report and that further refinement or justification for these values would be desirable prior to release of a MOPS. Jeff took an action (*reference Action 53 in the 'EUROCAE WG-95 - Action Items' file)* to provide a draft of Section 8 suggesting that we need more data for the next meeting. Generally, it has been agreed that it would be beneficial to define a 'one size fits all' standard.

There was also a request to make sure it is clear that this is a situational awareness means and not an alerting function. The request was to make sure we clear up all 'protection' wording or 'Alerting' function text throughout the document. Luke and Camille will take this action. *<reference Action 55 in the 'EUROCAE WG-95 - Action Items' file>*

HMI discussions

There was a lot of general discussion regarding the HMI study put together by Airbus and also some evaluations done by Rockwell Collins. There will be more evaluations done prior to the next meeting with both the Honeywell and Rockwell Collins displays files and more discussions in the final meeting in Toulouse. Some general concerns brought up were not necessarily with the current HMI being proposed, but in general with the proliferation of icons/symbology being driven onto the WXR display. Boeing will formalize this information for the next meeting.

With Boeing Propulsion team

The Boeing Propulsion team and meteorologist joined the meeting for an hour or two which lead to further discussion surrounding the current lower threshold of 1 g/m^3. The information provided was that, based on the engine event database and information in Appendix C *[CS-25 - Amendment 17_0_Appendix C - Atmospheric Icing Conditions]*, airplanes are flying in 0.8 g/m^3 all the time and not having issues…so it would seem that the threshold should be above that.

The theory provided by Boeing's engine's team was as follows:
From the engine perspective, flight through lower densities of ice crystals [we will say < 1 g/m3] is a pre-condition or contributing factor in reducing the *thermal margins [pulling heat out of various stages of the engine]* within the engine. These reduced margins result in an engine that is now susceptible to higher concentrations of ice crystals triggering ice accretion. When the airplane then flies through or near higher concentrations of ice crystals, the engine begins to accrete ice in various stages of the engine resulting in any number of engine events. Matt (Boeing's primary Meteorologist for this subject) is currently re-evaluating all of our engine events with this theory in mind and validating all of our information and the theory based on that data. Matt is trying to wrap up that data review this year.

There was some discussion in the room that one possible solution may be to use in-situ data for the moderate 'pre-conditioning' ice crystal conditions, then just use the radar to indicate areas of higher

concentrations of ICI. After some discussion, it was recommended that the radar still be used for the lower threshold, but that the radar may use that information to determine when to display the lower concentrations (i.e. only display the lower threshold when you are within some distance of higher concentrations).

It was noted that the Boeing propulsion team and meteorologist were using the term 'core' differently than those in the room. The Boeing propulsion team used the word 'core' to represent an infrared (IR) temperature detected core based on satellite data (i.e. breaking through the tropopause plus some additional temperature drop).

The discussion also led to the Boeing team informing the team that pilots have indicated areas of turbulence around these IR cores where engine events have occurred.

There was some further discussion on the one engine that has been tested for effects of ice crystals on the engine. Jeanne noted that the engine that has available data, the root cause for the failure was an ice accretion event that blocked the core of the smaller engine. It was noted that with the larger engines, it tends to be accretion and shed of ice that causes damage.

Jeanne also noted the curves in CFR 14 Part 33, Appendix D may change (downward) (i.e. 2 g/m3 at 20 degrees c may be come 1 g/m3). Luke took an action to understand these proposed changes and provide information (including the presentation from the Flight Ops symposium) to the team and in the document as needed. *<reference Action 58 in the 'EUROCAE WG-95 - Action Items' file>*

In the end, Jeanne's recommendation (and Boeing Propulsion's recommendation based on the engine event database), was that the focus of this initial activity should be on the conditions at cruise altitudes.

One idea brought forth by Jeanne was to have a near term fix to implement the procedure being worked by crews today into the WXR automatically (i.e. if reflectivity at flight level, automatically tilt down into the freezing level and display amber/red return areas for crews to avoid). The group acknowledged that there are some underlying issues with this proposal, but that maybe it could be used in part with the actual detection of IC at flight level.

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Steve updated us on recent findings since our last meeting that corrected a conversion factor in their data that corrects some discrepancies in the data which now lines up with the rest of the industries work (RASTA, Environment Canada). The conclusion was that there does seem to be a reasonable relationship between reflectivity and ice water content.

There was discussion on making sure that the data provided by Steve is in line with the theoretical data provided by Jeff in Section 5 of the document in terms of dBz/TWC and range. Steve was going to work to provide what data he could to the team (and to Jeff) to ensure everyone's numbers line-up.

Steve also noted that no specific radar or radar technology has been selected for their next flight test (3Q/4Q2017 - 1Q2018). Potentially, multi-frequency or multi-polarization radar would be used. The decision will be made in the next few months.

We went through the whole document and accepted or rejected all comments that were previously made. All remaining work is primarily in the bibliography section, cleaning up the document, agreeing the guidelines for display symbology, proposing section 8 text, formulating reasonable values for the must detect/must not detect probabilities and validating we have the right thresholds in our operational goals sections.

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Action Items:

#	Text	Actionee	Due date	Comment
8	Writing Assignment - Radar constraints/expected results in regard to Section 5 requirements and assumptions. Jeff will coordinate with other radar suppliers and Gosniias with a draft and others will provide comment and supporting material. [Section 5 Draft]	Rockwell Honeywell	23-Sep-16	The majority of this section is complete and in the working draft. The remaining portions of the section will be worked prior to the next meeting. 7/12/16 - Major updates reviewed today, there are a couple of remaining items that will be updated prior to the next meeting.
37	Contact other OEMs to make them aware of the project and see if they have any information to contribute regarding IC events.	Dawn William Jeff Brian C.	23-Sep-16	Dawn/Jeff still working to get contacts at other aircraft OEMs: Gulfstream & Embraer (Dawn) Bombardier (Jeff) Cessna (William) Brian to check into seeing if airlines can contribute any information from other aircraft/airlines events (likely more probe issues than engine issues). 7/12/16 - Leave this item open. Brian/Jeff to coordinate on additional contacts within Bombardier and any additional events that can be provided to NASA. Jeff to also contact Cessna for any relavent events.
26	Provide feedback on the results of the flight test campaign to be held in January 2016 to NASA to ensure results are comparable and in line with existing events. Recommendations can be made as to whether things line up or further evaluation/data sets are	HAIC Members (Jan/Fabien) NASA (Steve)	29-Jul-16	Due date to be updated to allow for more time to process the data and provide to NASA - New Due Date - TBD? 7/12/16 - Steve to follow up with Fred to determine what additional information would be helpful to

	needed. There are two aspects to this action: (1) microphysics and (2) reflectivity data analysis			complete this action.
22	LRA SG members to ensure that the bibliography list is complete & provide all available/shareable data to the secretary to post to the EUROCAE workspace.	All WG-95 LRD members	9-Sep-16	
16	OEM to contact their test pilots participation in the working group (at least consultation)	Upon Request TBD	As needed	
44	Brian (ALPA) will work to see if additional data can be provided on events that have been recorded amongst the ALPA members.	Brian	17-Jun-16	7/14/2016 - Brian has provided the data to NASA.
45	Steve to provide graphs showing plots of time vs. IWC for the events described in his presentation for Pitot anomalies to help show IWC over time for each event.	Steve Harrah	29-Jul-16	
46	Steve to produce a graph similar to the ones he provided for reflectivity against IWC, but separating the data out by tropical storm data sets vs. typical convective systems (MCS systems).	Steve Harrah	29-Jul-16	7/12/16 - Steve provided a sample graph for the team to review during the meeting. Can more data be provided to the team for various data sets (i.e. primarily above convective vs. not, tropical storm data vs. typical convection driven sets, etc.)

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47	Camille to provide additional information to NASA for a subset of probe events to help in the validation/evaluation of the models for HIWC.	Camille	16-Sep-16	7/12/16 - No official data available yet. Camille to see if more data can be made available to NASA.
49	Honeywell to review the existing January 2016 flight test data to provide a rough order of magnitude assessment of the systems probability of detection in comparison to the current 80/20 probabilities.	Jan	23-Sep-16	
50	NASA to review their existing flight test data and provide the data to the radar OEM's to perform a similar assessment as Action 49.	Steve Harrah	15-Aug-16	
51	The Radar OEMs to provide input in section 5 (or other) describing limitations in the radar's ability to distinguish Ice Crystals at low altitudes and/or temperatures (i.e. due to terrain, mixed phase returns, etc.)	Jeff Finely Paul/Brian	31-Aug-16	
52	NASA to review their existing flight test data to provide a summary (or detailed information if available) of the Ice Crystal concentrations at which their probe events occurred	Steve Harrah	29-Jul-16	
53	Jeff to craft wording in the recommendation section in Section 8 regarding the desire	Jeff	31-Aug-16	

	to have more concrete data for the given thresholds prior to completion of a MOPS.			
54	Writing Assignment - Executive Summary needs to be drafted for our next meeting.	Camille	19-Sep-16	
55	Scrub the document to make sure the document is cleaned up for the following re-occurring text: 'high altitude' removed throughout 'prolonged' removed throughout 'protection' and 'alerting' scrubbed to ensure it remains clear this is a situational awareness tool automatic activation should be clarified (means display of information vs. activation the feature within the box).	Luke	19-Sep-16	
56	Luke and Camille to harmonize Figures in Section 4.	Luke Camille	19-Sep-16	
57	Honeywell/Rockwell to review data to be provided by NASA and come up with some suggested reasonable numbers for the must detect/must not detect values	Jan Jeff	31-Aug-16	
58	Get with Jeanne on proposed updates to Appendix D and include in appendix A if needed.	Luke	31-Aug-16	
59	Luke to provide the current ops procedure being used today for	Luke	29-Jul-16	

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	avoiding ICI conditions.			
60	Provide feedback on the current HMI based on the Ballard files provided by Honeywell and to be provided by Jeff.	Luke Camille	31-Aug-16	